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ABSTRACT

The purpose of this study was to ascertain middle school student and science teacher perceptions of the science inquiry experiences fostered in their science classrooms and to develop a science inquiry profile based on survey information from students and teachers. Nine hundred seventeen middle school (grades 6-8) science students and their thirteen science teachers responded to surveys used to characterize science inquiry learning opportunities in the middle school science classes. Survey information was used to profile perceived inquiry experiences and serve as a benchmark for the initiation of longitudinal data collection by the study district. The survey results indicated that while both students and teachers have experiences in elements of science as inquiry, students viewed the lesson and activity as a teacher choice. Also, there was limited use of very basic science equipment. The findings suggest that survey information from both students and teachers should be utilized to inform instruction, assessment, and curriculum design. Contains 17 references. (DDR)

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Profiling Middle School Science Inquiry Experiences Using Student and Teacher Survey Data

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Abstract

A profile of middle school science inquiry experiences was developed for a small, rural, midwestern school district. Nine hundred seventeen middle school (grades 6-8) science students and their thirteen science teachers responded to surveys used to characterize science inquiry learning opportunities in the middle school science classes. This survey data provided a benchmark for longitudinal data collection in the district and also served to provide a contextual framework for interpretation of student performance on science assessments. Findings from the survey data, indicated that while middle school students did report having opportunities to practice science inquiry, the teachers reported that much of this practice was contextual. This kind of baseline information can be linked to assessment outcomes to examine questions related to transfer of skills and abilities across various inquiry contexts. Recommendations from the survey data and study findings included recommendations such as more attention be devoted to discussing, reading, and writing in the content area. Increased access to technology to support various aspects of inquiry was also reported as a need perceived by teachers.

Introduction

In the recent years of science education, the engagement of students in science inquiry is a requisite of major reform projects. Science as inquiry, as described in the National Science Education Standards (NSES) (National Research Council [NCR], 1996), involves both the opportunity and ability to conduct inquiry along with the development of understandings about inquiry. The development of the ability to think and act in ways associated with the processes of inquiry includes key elements such as: asking questions; planning and conducting an investigation; using appropriate tools and techniques; thinking critically and logically about the relationships between evidence and explanations; constructing and analyzing alternative explanations; and engaging in and making scientific arguments.

Full inquiry involves asking a question, completing an investigation, answering the question, and presenting the results to others. It is recommended that students recognize relationships between explanation and evidence and that background theories guide the design of investigations, the types of observations, and data interpretations. For grades five and above, the use of mathematics is recommended in all aspects of inquiry.

The Benchmarks for Science Literacy on science inquiry, describe inquiry as a complex process that is characterized by subtleties that go beyond making observations, doing experiments, and following a rigid set of steps (Association for the Advancement of Science [AAAS], 1993). As stated in the Benchmarks for Science Literacy, advancement of science often depends on the enterprise as a whole (AAAS, 1993). Both documents, the NSES and the Benchmarks for Science

Literacy, have expectations related to students' development of critical thinking abilities necessary to evaluate scientific information.

What students experience in the classroom is largely determined by the teachers' instructional goals and objectives; the knowledge and processes teachers make available; the books, materials, and equipment teachers use; the classroom activities teachers arrange; the quality of the teachers' background, training, and experience; and the support and resources available to teachers (Oakes, 1990; LeMahieu & Leinhardt, 1985; Shavelson & Stern, 1981). Opportunities for students to gain experience in science as inquiry must be facilitated in a variety of contexts if students are to develop understandings related to the doing science. To ascertain whether science inquiry opportunities are present in classrooms, the use of survey data can be used to profile the inquiry opportunities from both student and teacher perspectives. Linking these opportunities to performance on assessments is also very much of interest.

Study Purpose

The purpose of this study was to ascertain both middle school student and middle school teacher perceptions about the science inquiry experiences fostered in their science classrooms and to develop a science inquiry profile based on this survey information. Past research provides convincing and consistent support for the predictive validity of student perceptions in accounting for appreciable amounts of variance and in learning outcomes beyond those attributable to student characteristics such as gender or ability (McRobbie & Fraser, 1993). Sizable associations between several inquiry skills and science-related attitudes and classroom environment dimensions were reported by Fraser (1994) and Fraser and Fisher (1982). Survey information from this study was used to profile perceived inquiry experiences and served as a benchmark for the initiation of longitudinal data collection by the study district. Linkage of this survey data to student performance on assessments was also a component of a more extensive study (Enger, 1997a; 1997b).

Study Samples

For science inquiry profile development, two deliberate samples were selected from a small, rural, midwestern school district engaged in science education reform. The two sample groups for the survey study were: (1) 917 middle school students from grades six, seven, and eight and (2) 13 middle school science teachers. The study school district had a well established curriculum plan which was utilized by the district teachers and curriculum director for curriculum design and development. Variability in the science classrooms would be expected to some degree based upon differences in teachers and students, but the curriculum framework provided a level of commonality across classrooms and teachers. At the time of the study the district had been

affiliated with a major science education reform project for seven years. The project was grounded in constructivist philosophy and involved teachers in leadership roles (Brooks & Brooks, 1993; Yager, 1991).

Methodology

Middle school student and middle school teacher perceptions of their science inquiry experiences were sampled with either a student or teacher form of survey developed to align with the construct of science inquiry as set out in the NSES and in the Benchmarks for Science Literacy. The survey information from both middle school students and their teachers made comparisons of perceptions possible. The two survey instruments, which were submitted to an expert panel for a review and revision process, were developed specifically for the study. Middle school students rated their science inquiry experiences on an integral scale from 1 to 5 with the respective descriptors of never, seldom, sometimes, often, and very often. All of the student survey data were reported by both percentage and item means.

Middle school science teachers were asked to respond to the extent to which they perceived that students had practice in science inquiry; the importance and emphasis placed on skills and abilities relative to inquiry; and the components in the classroom setting that were relative to the support of science inquiry. Teacher data were reported by frequencies, and comparisons were made with student reports.

Profile Development of Middle School Science Inquiry

Student Perceptions of Working Together

Based upon middle school student responses to survey items that solicited information about classroom organization for collaboration, work in groups or teams was often utilized as indicated in Table 1. Students reported often doing activities and experiments in science classes, but they less frequently designed experiments or activities themselves. Data summarized in Table 2 provide evidence of student perceptions that the teacher was the decision-maker for science activities and lesson selections.

Insert table 1 about here

Insert table 2 about here

Student Perceptions of Inquiry Opportunities

The profile of inquiry opportunities that emerged from questions related to inquiry experiences showed that students often engage in inquiry related experiences in their middle school

science classes. Table 3 data provide evidence that hypotheses or questions are tested, predictions made, and data are collected. Students also discuss their work and reasons for anomalies in outcomes, and students report that they do try experiments more than one time to check their results. Students utilize writing skills but to a lessor extent graph data from their work. This could be an area to target for more practice or incorporation of activities that necessitate graphic representation. The least frequently reported inquiry opportunity was the setting up of their own experiments or activities, and this is an area that might be flagged for improvement in facilitating student work in this area.

Insert table 3 about here

The NSES for grades K-4 recommend that students utilize simple instruments, such as magnifiers, thermometers, and rulers to accompany scientific inquiry. In grades 5-8 more sophisticated tools and techniques should be utilized including computer hardware and software. As set out in Table 4, the profile of equipment and material usage raises potential questions about the nature of the opportunities that students experience. The kinds of activities that students access in their classrooms may warrant some inspection to see that students can and do use some very basic equipment and materials. Access to computers and related technology in the classroom appears to be a flag area. About 31% of the students report that they seldom use a microscope, and 39% of the students report that that never use a microscope. The utilization of living materials also is potentially a flag item, since to develop understandings of life science, experience with organisms would seem essential.

Insert table 4 about here

Scientific literacy development has been a mandate from a number of forums in the scientific community and even those outside this community. When some potential science literacy enhancement opportunities are profiled as in Table 5, this is an area that could be flagged for attention. If the categories of seldom and never are collapsed across each of the five items, at least 50% of the students report never reading about and discussing the work that scientists do or seldom have classroom visitors come talk about science. Further it appears that students do not with any great frequency discuss science from the newspapers and magazines or access the library for science information.

Insert table 5 about here

Teacher Perceptions of Inquiry Opportunities

Nine of the 13 middle school science teachers reported that their students did have on-going practice in scientific inquiry while four of the teachers reported practice in certain contexts. As reported in Table 6, elements which are inherent in the process of scientific inquiry may be addressed in contextual practice which raises the question of transferability to other problems and situations. Six of the teachers in the sample indicated that students had limited or no practice in keeping a laboratory log or journal. Reading or discussing the work of scientists receives less attention than other areas in the science class in this sample of teachers.

Insert table 6 about here

The availability of technology to support the science classroom was also surveyed, and this sample of middle school teachers perceived that lack of or limited availability of computer-related technology accessible to their classroom did present limitations. These perceived limitations reported in Table 7 potentially impact the kinds of inquiry opportunities that students access in the classrooms.

Insert table 7 about here

Seven of the sample teachers reported students had limited practice in reading and discussing the work of scientists, and seven reported a limitation in the availability of print resources for students. While not all teachers perceived limitations in print-type materials as presented in Table 8, this may be a target area for enhancing availability of materials if the school budget would allow.

Insert table 8 about here

Discussion

The survey results in and of themselves provide evidence from the students' perspectives that they do have experiences in elements of science as inquiry. Teacher reports also corroborate this, with practice being reported as contextual in nature by the majority of teachers. Students view the lesson and activity choice decisions as being made by the teachers, and teachers confirmed this in that they reported almost always making the lesson and activity decisions (Enger, 1997a). The limited usage of very basic science equipment reported by the middle school classes raised some questions as to the nature of the inquiry activities. Six of the 13 teachers surveyed reported that

lack of a separate laboratory was a limitation (Enger, 1997a), and this could be a potential limitation for the kinds of laboratory experiences fostered in some of the classrooms.

If science literacy is a goal of science education, then the lower frequency with which these students report reading and discussing about the work done by scientists or science presented in newspapers, by the media, and in other print materials would seem to warrant increased attention. The lack of the availability computers and internet access could very well confound the frequency with which students seek out science related materials.

Recommendations

The survey information should be utilized to inform instruction, assessment, and curriculum design. The survey voice from the students provides information about their perceptions of their experiences. Taken into account by teachers and curriculum personnel, the student information can provide input for potential changes in the inquiry opportunities. Experience with a variety of contextual settings in which inquiry is experienced, and increased use of simple instrumentation would be recommended. As Bruer (1993) noted, ability to transfer a solution from one problem version to another occurs only when explicit linkages are made between the two problems. If inquiry experiences are very contextually based, then it may be imperative that the teacher work with students to establish linkages across contexts. Areas in data collection and, in particular, data representation could be beneficial emphases that could enhance student performance on assessments (Enger, 1997b). Resnick and Resnick (1992) see assessment and instruction linkage as a very positive tool for creating schools truly capable of teaching students to think.

Johnson-Laird (1983) found that both adults and children have difficulty transferring a skill from one context to a similar context. In studies conducted on skill transfer, subjects were able to transfer between contexts only after the experimenter made explicit the way in which the strategy applied to the new situation. On studies such as these and those on expert-novice problem solving strategies, a recommendation would be that students have experience in a wide variety of inquiry situations to build expert knowledge and make linkages. Subtle differences in problem phrasing were found to substantially alter students' ability to solve simple word problems (De Corte, Verschaffel, & DeWin, 1985). Snow and Lohman (1993) note that much of what applies to mathematical problem solving also applies to the study of knowledge structures and problem solving in physical science. To build the linkages, the linkages must be made explicit through reading, writing, and discussion.

When and where possible and appropriate, students' questions and ideas should be considered for making the inquiry experiences relevant to the student and connected to science that can initiate the students as researchers. This may require teachers' attention in identifying potential areas of study for which students can actually pose and research more of their own questions.

The survey data provide a view that the availability of technology serves as a limitation in these classrooms. With the survey data, teachers have a collective voice in seeking grant funding or budget support for technological improvements. The school district did move to address the technology limitation in the year after this study was conducted. By utilization of survey results, a school district can establish a benchmark and identify areas for potential curricular changes. The linkage of experiences to outcomes in assessments can be a complex task. While the examination of the experiences that appear to correspond to domains measured provides some answers, the process often raises difficult questions when trying to interpret the experience-performance relationship.

A limitation of this study may be the selection of a deliberate sample, but the surveys can be easily adapted for use in any school district. The kind of information collected can then be used to focus on the kinds of inquiry opportunities supported in classrooms, and this information can inform instruction and can be linked to assessments. The data can be used to identify needs in material and supplies in support of instruction.

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Table 1

Middle School Student Report of Work in Groups

How often do you do the following?	Response by Percent					Mean	S.D.
	Very Often	Often	Sometimes	Seldom	Never		
Work in groups or teams	28.1	40.1	26.4	5.0	0.3	3.91	.88
Work in groups or teams to do science activities	30.2	38.5	25.2	5.2	0.9	3.92	.91
Work by yourself	15.5	22.2	38.8	22.1	1.3	3.28	1.02
Work by yourself when you do activities and experiments	3.4	12.6	32.8	41.5	9.6	2.59	.94
Design you own activities or experiments	3.5	10.5	33.8	36.4	15.8	2.49	1.04

1= Never, 2= Seldom, 3= Sometimes, 4= Often, 5= Very Often
N = 917

Table 2

Middle School Student Report of Science Lesson and Activity Selection Decisions

Who decides what science lessons and activities are done in science class?	Response by Percent					Mean	S.D.
	Very Often	Often	Sometimes	Seldom	Never		
The teacher decides what the science lessons are about.	47.5	30.7	15.7	3.4	2.7	4.17	.99
The students in the class decide what the science lessons are about.	3.4	6.5	22.3	35.4	32.4	2.13	1.05
The teacher decides what science activities and experiments we do.	49.4	32.9	13.3	3.1	1.3	4.26	1.06
The students in the class decide what science activities and experiments we do.	3.5	6.9	22.1	35.0	32.6	2.14	1.03

1= Never, 2= Seldom, 3= Sometimes, 4= Often, 5= Very Often
N = 917

Table 3

Middle School Student Report of Inquiry Opportunities

Type of Skill and/or Ability	Response as Percent					Mean	S.D
	Very Often	Often	Some-times	Seldom	Never		
Testing a hypothesis or question in activities or experiments	26.2	34.5	26.2	11.0	2.1	3.72	1.04
Making predictions about what will happen before doing activities or experiments	35.3	33.5	22.0	7.4	1.7	3.93	1.01
Controlling variables when doing lab activities or experiments	18.2	30.9	37.3	10.2	3.4	3.50	1.01
Setting up a data table when doing activities or experiments	34.4	35.2	21.1	6.8	2.5	3.92	1.02
Writing down their own information from a science experiment	19.0	32.5	29.4	14.1	5.0	3.46	1.10
Writing down their own observations from an experiment	39.4	34.4	17.5	6.7	1.9	4.03	1.00
Writing about the experiments that are done in a notebook, log, or journal	23.4	25.7	23.4	14.6	12.8	3.32	1.32
Graphing numbers from their experiments	10.7	21.9	32.7	25.6	9.1	3.00	1.13
Discussing the results from their experiments	40.0	33.2	19.9	5.6	1.3	4.05	.97
Discuss reasons for outcomes different than predicted	27.2	33.2	22.8	12.0	4.4	3.68	1.13
Trying experiments more than one time to check their results	18.5	28.2	32.1	14.7	6.4	3.38	1.13
Setting up their own experiments or activities	6.1	20.0	36.9	27.9	9.4	2.86	1.04

1= Never, 2= Seldom, 3= Sometimes, 4= Often, 5= Very Often
N=917

Table 4

Middle School Student Report of Equipment or Material Usage

	Response by Percent						
Equipment or Material	Very Often	Often	Sometimes	Seldom	Never	Mean	S.D.
Balances or scales	5.3	15.5	3.9	24.3	20.7	2.61	1.14
Thermometers	4.0	13.6	21.0	25.9	35.5	2.25	1.19
Microscopes	3.1	7.0	19.2	31.4	39.3	2.03	1.07
Magnifying lens	2.0	9.0	24.0	30.4	34.6	2.13	1.05
Meter sticks or rulers	17.8	34.7	32.7	11.1	3.7	3.52	1.03
Timers or stopwatches	7.8	15.1	28.9	29.0	19.7	2.61	1.17
Graduated cylinders or other containers to measure liquids	15.2	20.4	29.9	21.0	13.5	3.03	1.25
Live plants or animals	3.4	13.3	26.3	26.0	31.0	2.32	1.25
Preserved plants or animals	2.9	10.3	19.1	26.4	41.2	2.07	1.13
Computers with probes or science software	3.1	9.9	18.9	29.7	38.4	2.10	1.11
Computer to word process	10.7	18.5	28.1	22.7	20.0	2.77	1.26

1= Never, 2= Seldom, 3= Sometimes, 4= Often, 5= Very Often
N = 917

Table 5

Middle School Student Report of Science Literacy Enhancement Opportunities

Type of Skill and/or Ability	Response as Percent					Mean	S.D.
	Very Often	Often	Some-times	Seldom	Never		
Reading about the research work that scientists do	7.0	12.8	27.5	36.0	16.7	2.57	1.12
Discussing the research work that scientists do	4.6	12.4	31.1	34.7	17.2	2.52	1.06
Have visitors come to the class to talk about science	2.7	6.0	21.8	41.7	27.7	2.14	.98
Go to the library/media center to find science information	5.1	12.6	22.2	29.2	30.8	2.32	1.18
Discussing science articles from newspapers or magazines	7.5	13.8	27.7	28.1	22.9	2.55	1.20

1= Never, 2= Seldom, 3= Sometimes, 4= Often, 5= Very Often
N = 917

Table 6

Teacher Perceptions of Inquiry Practice

Skill and/or Ability	On-going Practice	Practice in certain contexts	Limited Practice	Don't do this in class
Making observations	10	3	0	0
Using scientific inquiry	9	4	0	0
Making predictions	9	4	0	0
Drawing inferences	8	4	1	0
Collecting data	7	5	1	0
Using laboratory equipment	5	5	2	1
Using multiple science resources	5	3	5	0
Developing science hypotheses	4	9	0	0
Testing hypotheses	4	9	0	0
Controlling variables	4	9	0	0
Interpreting data from graphs	4	5	3	1
Graphing data	3	6	3	1
Posing researchable questions followed with an opportunity to investigate questions	2	8	3	0
Repeating experiments more than once to collect data for analysis	2	6	4	1
Keeping a laboratory log or journal (12)	1	5	5	1
Reading and discussing the work of scientists	1	4	7	1

N=13

Table 7

Teacher Report of Technology Availability

Availability of technology to support science learning:	Limited Availability **Does Limit**	Not Available **Does Limit**	Available & Adequate	Limited Availability Does Not Limit	Not Available Does Not Limit
The science classroom has:					
access to computers in the library for student use	11	1	0	0	1
science software	1	10	0	0	2
access to science video tapes	6	5	1	0	1
a printer	2	9	0	1	1
lab probes that interface with computer(s)	1	9	0	0	3
access to a laser disk player	8	0	3	2	0
access to science laser disks	8	1	3	1	0
internet access from the classroom	9	1	0	3	0
internet access available in the library, media center, or computer lab	9	1	0	3	0
a dedicated phone line in the classroom	6	2	3	2	0
access to computers in the computer lab for student use	7	1	1	2	2
computers in the classroom for student use	2	5	0	0	6
access to electronic searches of databases in the library or media center	5	1	2	4	1
a computer for teacher use	4	1	4	4	0

N=13

Table 8

Teacher Report of Print Support Materials

Availability of materials to support science learning:	Limited Availability **Does Limit**	Not Available **Does Limit**	Available & Adequate	Limited Availability Does Not Limit	Not Available Does Not Limit
The science classroom has:					
a variety of print resources for student use	**4**	**3**	5	1	0
science posters, photos, and models	**5**	**0**	7	1	0
current science reference materials in library or media center	**4**	**0**	5	3	1
popular press science periodicals in the classroom	**0**	**1**	8	4	0

N=13